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English Version

Tests for geometrical properties of aggregates - Part 3: Determination of particle shape - Flakiness index

Essais pour déterminer les caractéristiques géométriques des granulats - Partie 3: Détermination de la forme des granulats - Coefficient d'aplatissement

Prüfverfahren für geometrische Eigenschaften von Gesteinskörnungen - Teil 3: Bestimmung der Kornform - Plattigkeitskennzahl

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Foreword

This document (EN 933-3:2012) has been prepared by Technical Committee CEN/TC 154 “Aggregates”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 933-3:1997.

The following changes have been made to the previous edition:

a) the CEN Technical Specification has been adopted as European Standard;

b) the document has been editorially revised.

This standard forms part of a series of tests for geometrical properties of aggregates. Test methods for other properties are covered by the following European Standards:

EN 932 *Tests for general properties of aggregates;*

EN 1097 *Tests for mechanical and physical properties of aggregates;*

EN 1367 *Tests for thermal and weathering properties of aggregates;*

EN 1744 *Tests for chemical properties of aggregates;*

EN 13179 *Tests for filler aggregate used in bituminous mixtures.*

EN 933, *Tests for geometrical properties of aggregates,* consists of the following parts:

— *Part 1: Determination of particle size distribution — Sieving method;*

— *Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures;*

Part 3: Determination of particle shape — Flakiness index;

— *Part 4: Determination of particle shape — Shape index;*

— *Part 5: Determination of percentage of crushed and broken surfaces in coarse aggregate particles;*

— *Part 6: Assessment of surface characteristics — Flow coefficient of aggregates;*

— *Part 7: Determination of shell content — Percentage of shells for coarse aggregates;*

— *Part 8: Assessment of fines — Sand equivalent test;*

— *Part 9: Assessment of fines — Methylene blue test;*

— *Part 10: Assessment of fines — Grading of filler aggregates (air jet sieving);*

— *Part 11: Classification test for the constituents of coarse recycled aggregate.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard describes the reference method, used for type testing and in case of dispute, for determination of the flakiness index of aggregates. For other purposes, in particular production control, other methods may be used, provided that an appropriate working relationship with the reference method has been established.

This European Standard applies to natural, manufactured or recycled aggregates.

The test procedure specified in this part of this European Standard is not applicable to particle sizes less than 4 mm or greater than 100 mm.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 932-2, *Tests for general properties of aggregates — Part 2: Methods for reducing laboratory samples*

EN 932-5, *Tests for general properties of aggregates — Part 5: Common equipment and calibration*

EN 933-1, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Sieving method*

EN 933-2, *Tests for geometrical properties of aggregates — Part 2: Determination of particle size distribution — Test sieves, nominal size of apertures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
constant mass
mass determined by successive weighings performed at least 1 h apart and not differing by more than 0,1 %

Note 1 to entry: In many cases, constant mass can be achieved after a test portion has been dried for a pre-determined period in a specified oven (see 5.4) at (110 ± 5) ºC. Test laboratories can determine the time required to achieve constant mass for specific types and sizes of sample dependent upon the drying capacity of the oven used.

3.2
laboratory sample
sample intended for laboratory testing

3.3
particle size fraction(d_i/D_i)
fraction of an aggregate passing the larger (D_i) of two sieves and retained on the smaller (d_i)

Note 1 to entry: The lower limit for d_i may be zero.

3.4
test portion
sample used as a whole in a single test

4 Principle

The test consists of two sieving operations. First, using test sieves, the sample is separated into various particle size fractions d_i/D_i, as given in Table 1. Each of the particle size fractions d_i/D_i is then sieved using bar sieves which have parallel slots of width $D_i/2$.

The overall flakiness index is calculated as the total mass of particles passing the bar sieves expressed as a percentage of the total dry mass of particles tested.

If required, the flakiness index of each particle size fraction d_i/D_i is calculated as the mass of particles passing the corresponding bar sieve, expressed as a percentage by mass of that particle size fraction.

5 Apparatus

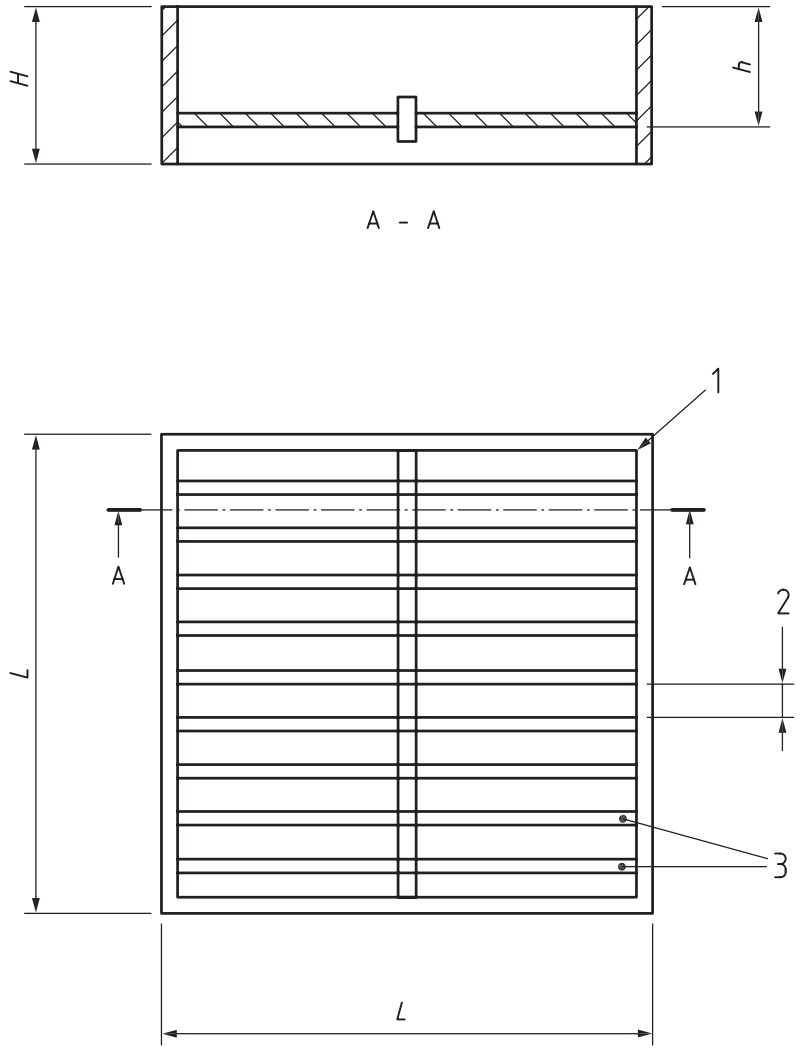
All apparatus shall conform to the general requirements of EN 932-5.

5.1 *Test sieves*, with square apertures, conforming to EN 933-2 with the following aperture sizes: 100 mm; 80 mm; 63 mm; 50 mm; 40 mm; 31,5 mm; 25 mm; 20 mm; 16 mm; 12,5 mm; 10 mm; 8 mm, 6,3 mm; 5 mm and 4 mm.

5.2 *Corresponding bar sieves*, comprising parallel cylindrical bars conforming to the requirements in Table 1. The tolerances on the width of slot shall apply to the entire length of each slot. An example of a bar sieve is shown in Figure 1.

Table 1 — Bar sieves

Particle size fraction d_i/D_i mm	**Width of slot in bar sieve** mm
80/100	50 ± 0,5
63/80	40 ± 0,5
50/63	31,5 ± 0,5
40/50	25 ± 0,4
31,5/40	20 ± 0,4
25/31,5	16 ± 0,4
20/25	12,5 ± 0,4
16/20	10 ± 0,2
12,5/16	8 ± 0,2
10/12,5	6,3 ± 0,2
8/10	5 ± 0,2
6,3/8	4 ± 0,15
5/6,3	3,15 ± 0,15
4/5	2,5 ± 0,15



Key

1 metal frame (outside wooden frame optional)

2 width of slot as specified in Table 1

3 cylindrical steel bars (usual diameter range from 5 to 15 mm depending on width of slot)

L = 250 mm to 300 mm

H = 75 mm

h = 55 mm to 65 mm

NOTE *L* being constant for all range of bar sieves, the width of the last slot cannot be equal to the nominal value. In all cases, it should be smaller than the nominal value.

Figure 1 — Example of a bar sieve

5.3 *Balance or scale*, accurate to ± 0,1 % of the mass of the test portion.

5.4 *Ventilated oven*, thermostatically controlled to maintain a temperature of (110 ± 5) °C or other suitable equipment for drying the aggregates, without causing any particle size breakdown.

6 Preparation of test portions

The laboratory sample shall be reduced in accordance with EN 932-2.

The mass of the test portion shall be as specified in EN 933-1.

Dry the test portion at (110 ± 5) °°C to constant mass. Allow to cool, weigh and record the mass as M_0.

7 Procedure

7.1 Sieving on test sieves

Using the appropriate range of sieves from those specified in 5.1, sieve the test portion as specified in EN 933-1.

Weigh and discard all particles passing the 4 mm sieve and retained on the 100 mm sieve.

Weigh and retain separately all the particles in each particle size fraction d_i/D_i.

7.2 Sieving on bar sieves

Sieve each particle size fraction d_i/D_i obtained from 7.1 on the corresponding bar sieve given in Table 1. This sieving operation can be carried out manually or mechanically and shall ensure complete separation.

Weigh the material from each particle size fraction passing through the corresponding bar sieve.

8 Calculation and expression of results

The results shall be recorded on test data sheets (see example in Annex A). Calculate the sum of the masses of the particle size fractions d_i/D_i and record as M_1.

Calculate the sum of the masses of the particles in each of the particle size fractions d_i/D_i which pass through a corresponding bar sieve of slot width $D_i/2$ and record as M_2.

The overall flakiness index *FI* is calculated from the following equation:

$$FI = (M_2/M_1) \times 100 \quad (1)$$

where

M_1 is the sum of the masses of the particles in each of the particle size fraction d_i/D_i, in grams;

M_2 is the sum of the masses of the particles in each particle size fraction passing the corresponding bar sieve of slot width $D_i/2$ in grams.

The overall flakiness (*FI*) shall be recorded to the nearest whole number.

The flakiness index for each particle size fraction FI_i shall be calculated, if required, from the following equation:

$$FI_i = (m_i/R_i) \times 100 \quad (2)$$

where

R_i is the mass of each particle size fraction d_i/D_i, in grams;

m_i is the mass of the material in each particle size fraction d_i/D_i which passes through the corresponding bar sieve of slot width $D_i/2$, in grams.

If the sum of the masses R_i together with the masses of any discarded particles and any size fractions that are not tested (see 7.1) differs by more than 1 % from the mass M_0 (see Clause 6), the test shall be repeated, using another test portion.

9 Test report

9.1 Mandatory data

The test report shall include the following information:

a) reference to this European Standard;

b) identification of the sample;

c) identification of the laboratory;

d) mass of test portion;

e) overall flakiness index *FI* to the nearest whole number;

f) sample reception date.

9.2 Optional data

The test report may include the following information:

a) name and location of the sample source;

b) description of the material and of the sampling procedure;

c) flakiness index FI_i of each particle size fraction to the nearest whole number;

d) sampling certificate;

e) date of test.

Annex A
(informative)

Example of test data sheet

Flakiness Index **EN 933-3**		**Laboratory:**		
Identification of the sample:		**Date of reception:** Operator:		
Test portion mass M_0 = g		Mass retained on the 100 mm sieve = g Mass passing the 4 mm sieve = g —— Sum of discarded masses = g		
Sieving on test sieves		Sieving on bar sieves		
Particle size fraction d_i/D_i mm	Mass R_i of particle size fraction d_i/Di g	Nominal width of slot in bar sieve mm	Mass m_i passing bar sieve g	FI_i $= (m_i/R_i) \times 100$
80/100		50		
63/80		40		
50/63		31,5		
40/50		25		
31,5/40		20		
25/31,5		16		
20/25		12,5		
16/20		10		
12,5/16		8		
10/12,5		6,3		
8/10		5		
6,3/8		4		
5/6,3		3,15		
4/5		2,5		
$M_1 = \Sigma R_i$ =		$M_2 = \Sigma m_i$ =		
$FI = (M_2/M_1) \times 100$ =				
$100 \times \frac{M_0 - \{\sum R_i + \sum(\text{discarded masses}) + \sum(\text{not tested fraction masses})\}}{M_0}$				< 1 %

Annex B
(informative)

Precision

The results of a cross testing experiment carried out by 20 laboratories in 1994, as part of a project (Project 134) funded by the European Community under the Measurements and Testing Programme, are given in Table B.1. The repeatability r_1 and reproducibility R_1 values have been determined for the three tested aggregates on the basis of test results obtained from duplicate test portions prepared by each laboratory from their laboratory sample and subsequently tested.

Table B.1 — Repeatability and reproducibility values for determinations of flakiness indexes (% by mass of flaky particles) of coarse aggregates

		Target *FI* value :		
Item	Symbol	Level 1	Level 2	Level 3
		10	30	50
Upper sieve size *D* (mm):		20	14	10
Number of laboratories included	*N*	18[1)]	18[1)]	18[1)]
Average *FI* value	*X*	8,8	29,2	51,1
Repeatability standard deviation	S_{r1}	0,68	1,37	0,80
Reproducibility standard deviation	S_{R1}	1,03	2,94	4,13
Repeatability limit	r_1	1,9	3,8	2,2
Reproducibility limit	R_1	2,9	8,2	11,6
[1)] The results of 18 laboratories out of 20 were accepted for precision data calculations.				

For other aggregate sizes or other levels of flakiness indexes, the repeatability and reproducibility values can be calculated using the following formulas:

$$r_1\left(\%\ \text{by mass}\right) = 0{,}0028\sqrt{\frac{FI\left(100-FI\right)D^3}{M}}$$

where

D is the aggregate size (mm),

M is the mass of test portion (kg)

$$R_1\left(\%\ \text{by mass}\right) = 0{,}95 + 0{,}226\,\text{FI}$$